2012 - JCR Evaluation Form

SPECIES: Bighorn Sheep

PERIOD: 6/1/2012 - 5/31/2013

HERD: BS609 - WHISKEY MOUNTAIN

HUNT AREAS: 8-10, 23

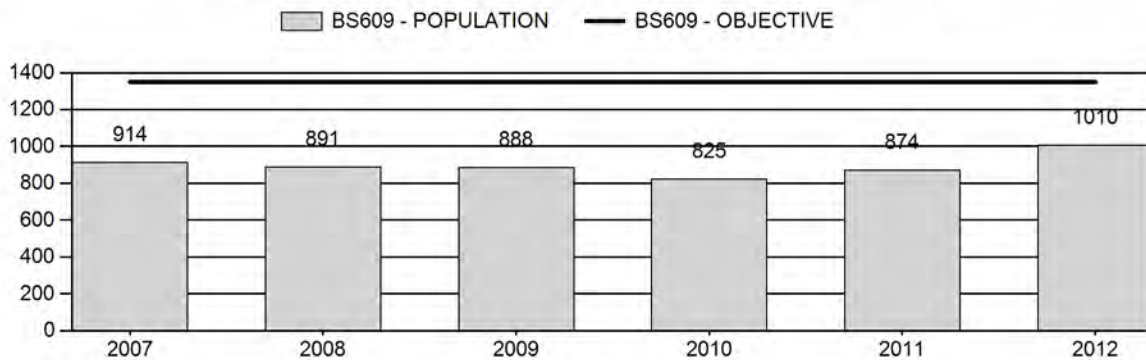PREPARED BY: GREG ANDERSON

	2007 - 2011 Average	**2012**	**2013 Proposed**
Population:	878	1,010	960
Harvest:	15	13	15
Hunters:	24	23	24
Hunter Success:	62%	57%	62%
Active Licenses:	24	23	24
Active License Percent:	62%	57%	62%
Recreation Days:	212	181	200
Days Per Animal:	14.1	13.9	13.3
Males per 100 Females	37	51	
Juveniles per 100 Females	26	42	

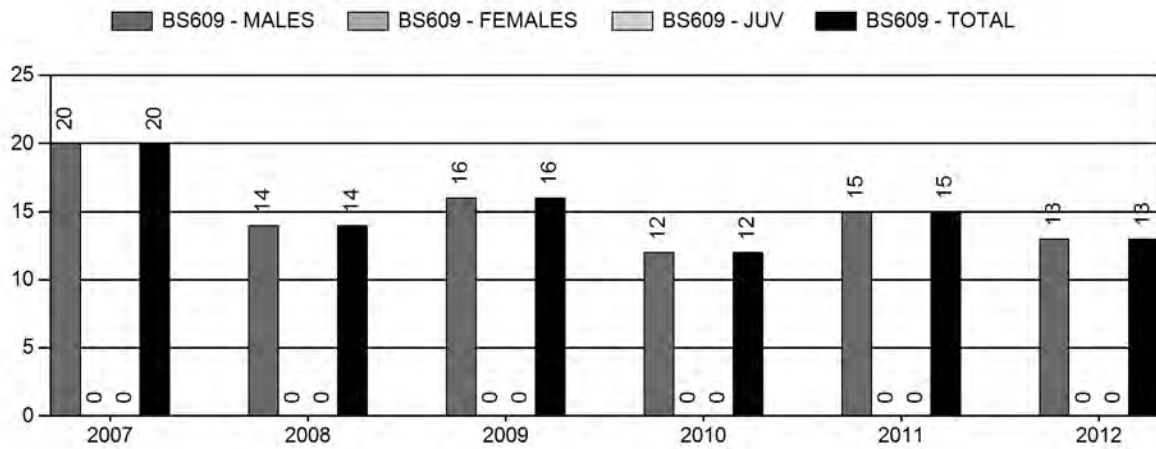|	
Population Objective:	1,350
Management Strategy:	Special
Percent population is above (+) or below (-) objective:	-25.2%
Number of years population has been + or - objective in recent trend:	10
Model Date:	2/22/2013

Proposed harvest rates (percent of pre-season estimate for each sex/age group):

	JCR Year	**Proposed**
Females ≥ 1 year old:	0%	0%
Males ≥ 1 year old:	6%	6%
Juveniles (< 1 year old):	0%	0%
Total:	1%	1%
Proposed change in post-season population:	+15%	-5%

Population Size - Postseason

BS609 - POPULATION   BS609 - OBJECTIVE

Harvest

Number of Hunters
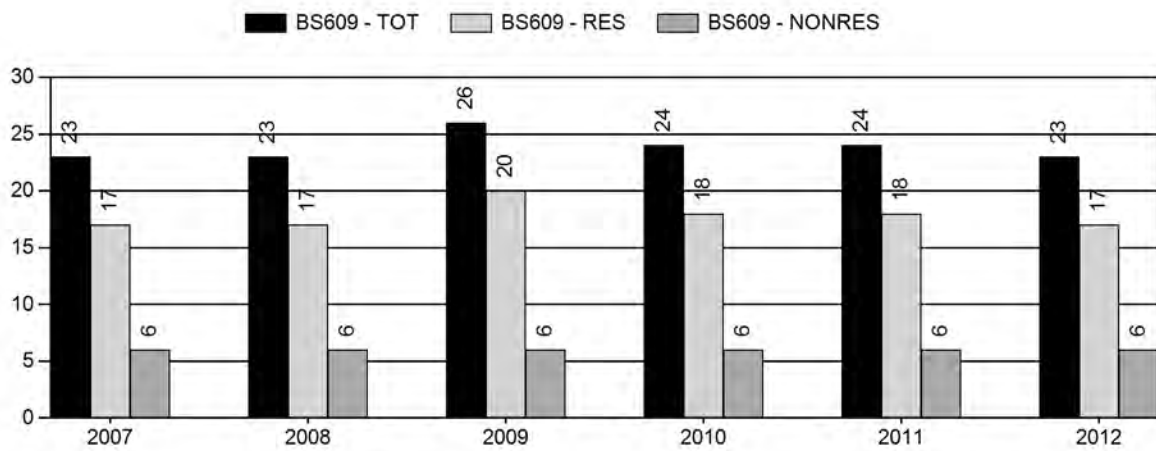
Harvest Success

Active Licenses

Year	Active Licenses
2007	23
2008	23
2009	26
2010	24
2011	24
2012	23
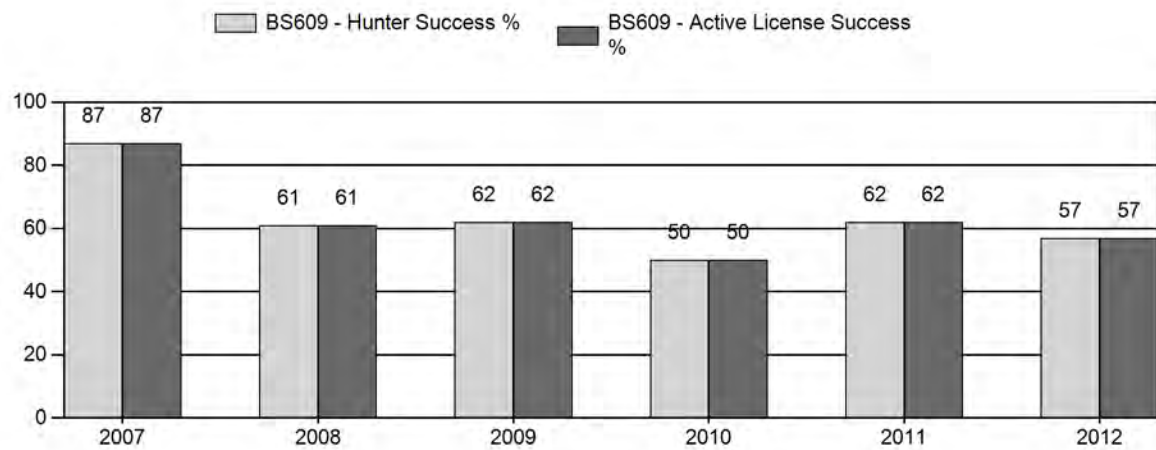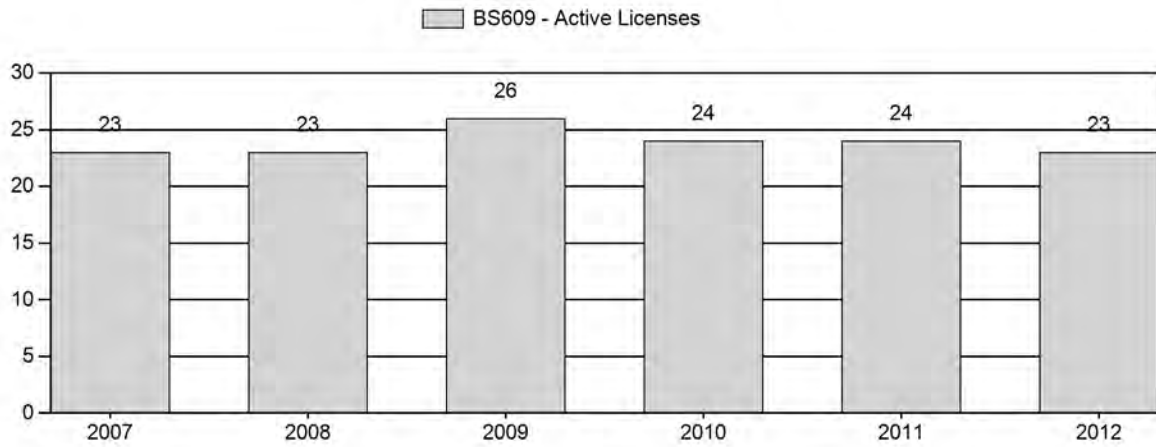
Days per Animal Harvested

BS609 - Days

Year	Days
2007	10
2008	14.9
2009	14.5
2010	17.6
2011	13.7
2012	13.9
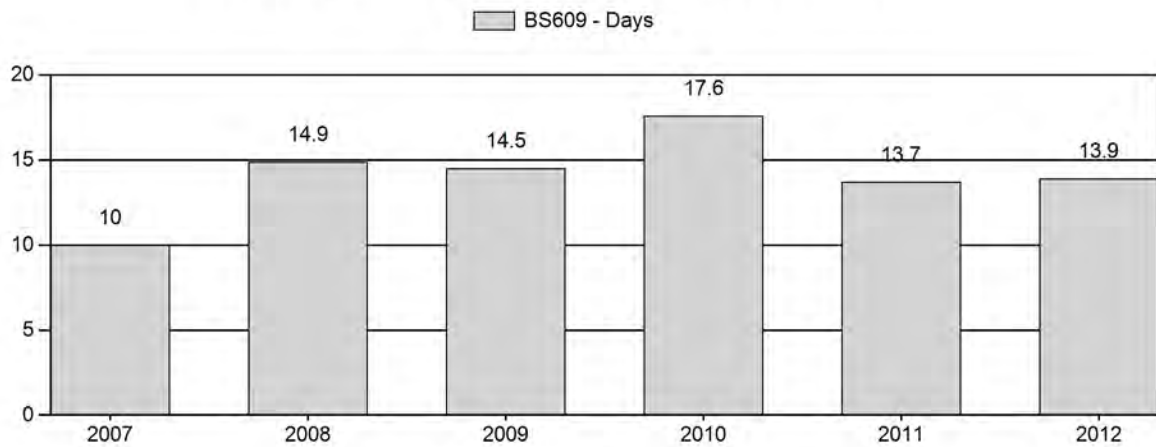
Postseason Animals per 100 Females

BS609 - Males   BS609 - Juveniles

Year	Males	Juveniles
2007	42	24
2008	36	25
2009	34	30
2010	30	21
2011	44	26
2012	51	42
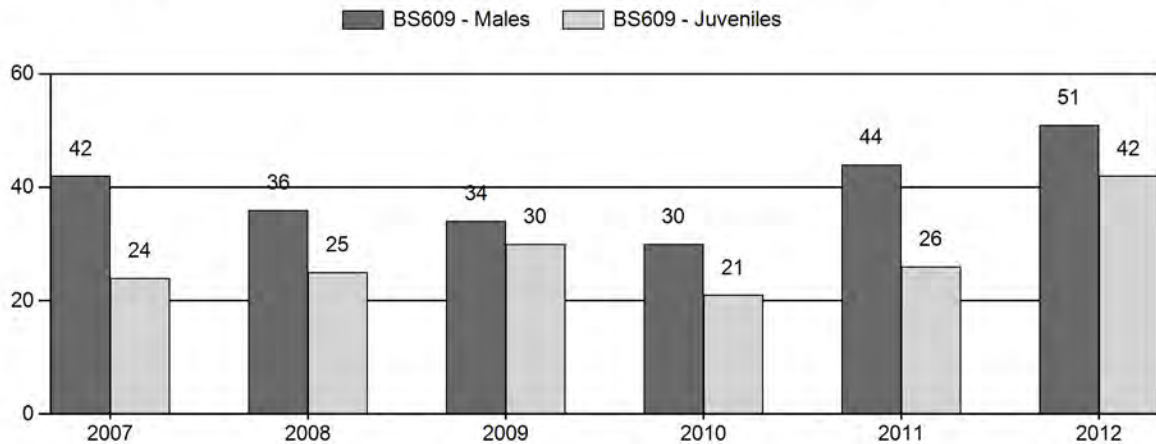
2007 - 2012 Postseason Classification Summary

for Bighorn Sheep Herd BS609 - WHISKEY MOUNTAIN

Year	Post Pop	MALES				FEMALES		JUVENILES		Tot Cls	Cls Obj	Males to 100 Females				Young to		
		Ylg	Adult	Total	%	Total	%	Total	%			Ylng	Adult	Total	Conf Int	100 Fem	Conf Int	100 Adult
2007	914	28	127	155	25%	368	60%	89	15%	612	332	8	35	42	± 3	24	± 2	17
2008	891	4	27	132	22%	366	62%	93	16%	591	298	1	7	36	± 3	25	± 2	19
2009	888	1	26	119	21%	348	61%	106	18%	573	264	0	7	34	± 3	30	± 3	23
2010	825	0	0	77	20%	255	66%	53	14%	385	240	0	0	30	± 4	21	± 3	16
2011	874	15	83	98	26%	223	59%	58	15%	379	328	7	37	44	± 5	26	± 4	18
2012	1,010	14	149	163	26%	320	52%	133	22%	616	496	4	47	51	± 4	42	± 3	28

2013 HUNTING SEASONS
WHISKEY MOUNTAIN BIGHORN SHEEP (BS 609)

Hunt Area	Type	Season Dates Opens	Closes	Quota	Limitations
8, 23	1	Sep. 1	Oct. 15	12	Limited quota licenses; any ram
9	1	Aug. 15	Oct. 15	4	Limited quota licenses; any ram
10	1	Aug. 15	Oct. 15	8	Limited quota licenses; any ram
Archery					
8, 23		Aug. 15	Aug. 31		Limited quota; refer to license type
9		Aug. 1	Aug. 14		Limited quota; refer to license type
10		Aug. 1	Aug. 14		Limited quota; refer to license type

Hunt Area	Type	Quota change from 2012
Total		

Management Evaluation
Current Management Objective: 1,350
Management Strategy: Special
2012 Postseason Population Estimate: ~1,000
2013 Proposed Postseason Population Estimate: ~1,000

Management Issues
The post-season population objective for this herd is 1,350 sheep and it is classified as special management. The objective has been in place since 2002. The herd has been below objective for over two decades following a catastrophic, all-age pneumonia die-off in 1991. The population continues to languish below objective primarily due to low recruitment associated with persistent lamb pneumonia. In 2012 the Department conducted a disease sampling project designed to document the presence and frequency of various pathogens in the population. Results from the disease sampling project are detailed in Appendix I.

Habitat/Weather
The Whiskey Mountain bighorn sheep herd occupies the northern Wind River Mountain Range. The majority of sheep in the herd unit winter at sites located along the very northern tip of the Wind River Mountains. Some sheep winter at high elevation along the continental divide and scattered throughout the west slope of the mountains. Sheep disperse from the wintering sites to populate the entire northern portion of the Wind River Mountains in the summer and fall. Much of the sheep habitat is located in wilderness areas and remains undisturbed. Important winter range sites in the upper Wind River Valley are part of the Department's Whiskey Mountain WHMA and are also relatively undisturbed.

Despite protection from development and disturbance, the condition of key winter range throughout this herd unit is still subject to change based on environmental conditions. In 2012, sheep range throughout the herd unit was impacted by extreme drought. Casual observations suggest vegetation production was quite low at high elevation summer range. Based on data from vegetation monitoring transects, herbaceous production on winter range was only 50% of 2011 production. The range had an unusually high amount of residual forage from the 2011 growing season that was difficult to separate from 2012 growth. As such, personnel believe the 2012 production estimate is artificially high.

Field/Harvest Data/Population
Although forage production throughout the herd unit was quite poor in 2012, lamb recruitment was exceptional with a lamb/ewe ratio of 42/100. This was the highest lamb/ewe ratio recorded in over a decade (Fig. 1). This was the second consecutive year of increased lamb/ewe ratios for the herd. Similarly, the ram/ewe ratio has been climbing for 2 years and was at a decade high level of 51/100 in 2012 (Fig. 2). Both the lamb/ewe and ram/ewe ratio indicate the population may have increased over the past several years.

A spreadsheet model was developed for this population in 2012. The model behaved predictably with the addition of data in 2013. For 2012, the TSJ, CA version of the model was selected to track the population. Indications are the model does a fair job of simulating the population. The model simulates a long, steady decline in the sheep population from the late 1990's through 2010. The population then increases slightly in 2011 and 2012. The 2012 population estimate is approximately 1,000 sheep. Personnel counted 616 sheep during classification surveys in January, 2013 so a population estimate of 1,000 seems reasonable. Additionally, the increased recruitment and ram/ewe ratios recorded over the past 2 years tend to indicate population growth.

Overall harvest success in the herd unit was 56% in 2012. This included success rates of 25% in hunt area 9, 75% in hunt area 10, and 55% in hunt areas 8/23. Success rates have fluctuated significantly in recent years, but no trends are evident to indicate hunt quality has changed dramatically. The average age of rams harvested declined in areas 8/23 and 10 in 2012 (Fig. 3). Despite the decline in 2012, no long-term decline is evident over the past decade. The average

age of ram harvest in hunt area 9 tends to fluctuate wildly since it is based on a very low sample. In 2012, a single 10 year old ram was harvested in hunt area 9 and accounts for the large increase in average harvest age.

Figure 1. Ten-year recruitment history in the Whiskey Mountain Bighorn Sheep Herd
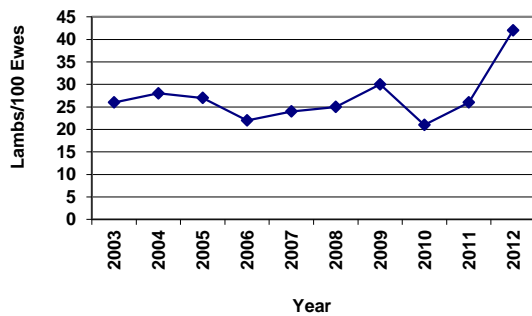

Figure 2. Ten-year history of the ram/ewe ratio in the Whiskey Mountain Bighorn Sheep Herd.
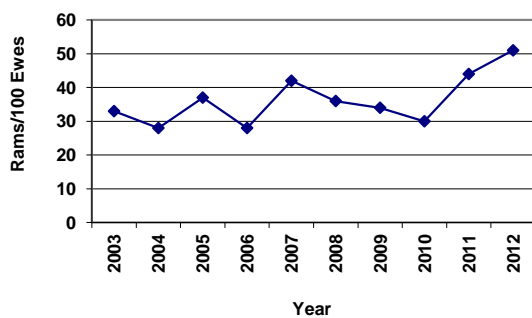
Figure 3. Average age of rams harvested in the Whiskey Mountain Bighorn Sheep Herd.
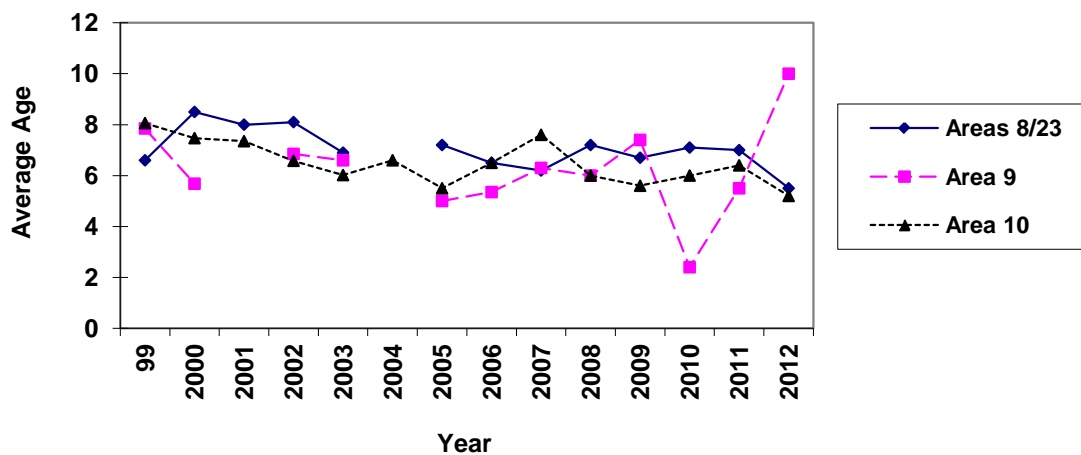
Management Summary

Overall, indications are there was little demographic change in this population over the past year. The population may have increased slightly given the high lamb/ewe ratio. This population remains well below objective. Given no indications of significant population growth, no changes are planned for the 2013 hunting season. With 24 licenses issued throughout the herd unit, hunters are expected to harvest 15 rams in 2013.

MODELS SUMMARY

		Fit	Relative AICc	Notes
CJ,CA	Constant Juvenile & Adult Survival	49	59	
SCJ,SCA	Semi-Constant Juvenile & Semi-Constant Adult Survival	49	60	
TSJ,CA	Time-Specific Juvenile & Constant Adult Survival	32	151	

Clear form

Check best model to create report
- ☐ CJ,CA Model
- ☐ SCJ,SCA Model
- ☑ TSJ,CA Model

Population Estimates from Top Model

Year	Posthunt Population Est.		Trend Count	Predicted Prehunt Population				Predicted Posthunt Population				Objective
	Field Est	Field SE		Juveniles	Total Males	Females	Total	Juveniles	Total Males	Females	Total	
1993				193	276	734	1202	193	226	734	1153	
1994				163	245	711	1120	163	188	711	1063	
1995				129	246	725	1099	129	220	725	1073	
1996				182	252	714	1148	182	224	714	1121	
1997				198	287	736	1221	198	260	736	1194	
1998				137	280	716	1132	137	250	716	1102	
1999				201	271	697	1170	201	241	697	1140	
2000				112	268	686	1066	112	232	686	1029	
2001				108	234	650	993	108	204	650	962	
2002				63	208	617	888	63	179	617	859	
2003				153	193	593	939	153	167	593	914	
2004				162	184	574	920	162	164	574	901	
2005				157	207	582	947	157	191	582	930	
2006				123	206	565	894	123	185	565	873	
2007				139	225	573	936	139	203	573	914	
2008				140	214	552	906	140	198	552	891	
2009				163	209	534	906	163	192	534	888	
2010				108	208	521	838	108	195	521	825	
2011				137	227	526	890	137	211	526	874	
2012				226	255	543	1024	226	240	543	1010	
2013				141	279	557	977	141	263	557	960	
2014												
2015												
2016												
2017												
2018												
2019												
2020												
2021												
2022												
2023												
2024												
2025												

Survival and Initial Population Estimates

Parameters:	Optim cells
Adult Survival =	0.916
Initial Total Male Pop/10,000 =	0.023
Initial Female Pop/10,000 =	0.073

MODEL ASSUMPTIONS	
Sex Ratio (% Males) =	50%
Wounding Loss (total males) =	10%
Wounding Loss (females) =	10%
Wounding Loss (juveniles) =	10%

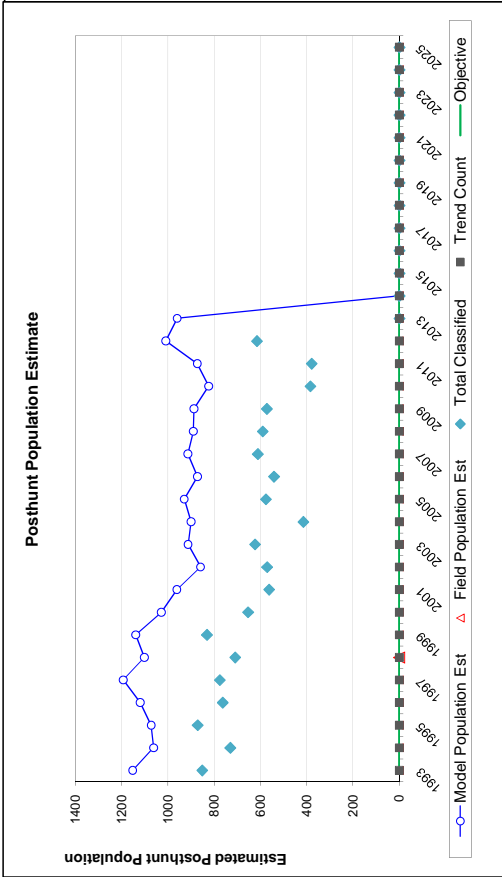| Year	Winter Juvenile Survival Rates			Annual Adult Survival Rates		
	Model Est	Field Est	SE	Model Est	Field Est	SE
1993	0.40			0.92		
1994	0.90			0.92		
1995	0.79			0.92		
1996	0.90			0.92		
1997	0.42			0.92		
1998	0.61			0.92		
1999	0.47			0.92		
2000	0.40			0.92		
2001	0.40			0.92		
2002	0.90			0.92		
2003	0.40			0.92		
2004	0.70			0.92		
2005	0.40			0.92		
2006	0.90			0.92		
2007	0.40			0.92		
2008	0.40			0.92		
2009	0.40			0.92		
2010	0.90			0.92		
2011	0.90			0.92		
2012	0.52			0.92		
2013	0.45			0.92		
2014						
2015						
2016						
2017						
2018						
2019						
2020						
2021						
2022						
2023						
2024						
2025						

Classification Counts

Year	Juvenile/Female Ratio			Total Male/Female Ratio			Juv	Yrl males	2+ Males	Females	Total Harvest	Harvest — Segment Harvest Rate (% of Prehunt Segment)	
	Derived Est	Field Est	Field SE	Derived Est	Field Est w/o bull adj	Field SE						Total Males	Females
1993		26.22	2.49	30.77	33.33	2.88	0	0	45	0	45	18.0	0.0
1994		22.97	2.37	26.48	21.78	2.29	0	0	52	0	52	23.3	0.0
1995		17.78	1.92	30.29	35.74	2.92	0	0	24	0	24	10.7	0.0
1996		25.51	2.55	31.39	29.15	2.76	0	0	25	0	25	10.9	0.0
1997		26.92	2.70	35.29	38.89	3.40	0	0	25	0	25	9.6	0.0
1998		19.09	2.22	34.92	34.92	3.20	0	0	27	0	27	10.6	0.0
1999		28.88	2.70	34.58	34.58	3.02	0	0	27	0	27	11.0	0.0
2000		16.35	2.14	33.76	40.87	3.72	0	0	33	0	33	13.6	0.0
2001		16.62	2.23	31.31	27.37	2.99	0	0	28	0	28	13.1	0.0
2002		10.19	1.63	29.08	25.36	2.74	0	0	26	0	26	13.7	0.0
2003		25.77	2.88	28.20	33.42	3.37	0	0	23	0	23	13.1	0.0
2004		28.30	3.70	28.58	28.30	3.70	0	0	18	0	18	10.8	0.0
2005		26.99	3.12	32.71	36.93	3.79	0	0	15	0	15	8.0	0.0
2006		21.82	2.71	32.76	27.90	3.14	0	0	19	0	19	10.1	0.0
2007		24.18	2.86	35.43	42.12	4.03	0	0	20	0	20	9.8	0.0
2008		25.41	2.95	35.88	36.07	3.66	0	0	14	0	14	7.2	0.0
2009		30.46	3.38	35.95	34.20	3.63	0	0	16	0	16	8.4	0.0
2010		20.78	3.14	37.41	30.20	3.93	0	1	11	0	12	6.3	0.0
2011		26.01	3.83	40.08	43.95	5.33	0	0	15	0	15	7.3	0.0
2012		41.56	4.29	44.24	50.94	4.90	0	0	13	0	13	5.6	0.0
2013		25.37	3.23	47.19	37.30	4.12	0	0	15	0	15	5.9	0.0
2014													
2015													
2016													
2017													
2018													
2019													
2020													
2021													
2022													
2023													
2024													
2025													

Posthunt Population Estimate

Estimated Posthunt Population

— Model Population Est   △ Field Population Est   ■ Total Classified
◆ Total Classified   ■ Trend Count   — Objective

Segment Harvest Rate

% of Prehunt Segment

— Total Males   — Females

Model vs Field Posthunt Total Male/Female Ratios

Total Males/100 Females

◆ Field Est   — Derived Est

Estimated versus Observed Survival Rates

Survival

— Model Annual Adult   ● Field Annual Adult
— Model Winter Juv   ■ Field Winter Juvenile

END

Comments:

250

BHS 609 - Whiskey Mtn.
HA 8-10, 23
Revised 9/02

N

WRIROUT

SSF

WRIRSSF

CRU/wYL

CRU/wYL

wYL

wYL

CRU/wYL

SSF

OUT

CRU/wYL

OUT

Appendix I. Whiskey Mountain Bighorn Sheep Disease Test Project: January/February 2012

Introduction

For well over a half century, wildlife managers, researchers, and veterinarians have documented die-offs of wild sheep associated with pneumonia. For several good summaries detailing the current state of knowledge regarding pneumonia in wild sheep populations, suspected causes, and vectors, see Besser et. al. 2012; Weehausen et. al., 2011; Schommer and Woolever, 2008. There is strong consensus among the scientific community that pneumonia outbreaks and associated mortality in wild sheep populations can be traced to several species of bacteria, notably; *Mannheimia haemolytica, Pasturella multocida, Bibersteinia trehalosi, and Mycoplasma ovipneumoniae*. All 4 of these bacteria species have been identified in samples taken from pneumonic sheep. Following is some background information on each of these bacteria.

Bibersteinia trehalosi: Although this bacterium has been blamed for some past bighorn sheep die-offs, more recent research indicates it may not be as detrimental to sheep populations as once thought. It is fairly easy to culture in the lab and may have been identified in past die-offs simply because it was easy to identify and outcompeted other bacteria on culture plates.

Pasturella multocida: Again, this bacterium has been implicated in past bighorn sheep die-offs. Researchers now believe we need to distinguish between two varieties of this bacterium. One type of *P. multocida* produces a substance known as leukotoxin. This substance essentially poisons white blood cells that are attacking foreign bodies (i.e. bacteria). The white blood cells then disintegrate and release the poison which in turn destroys neighboring cells in an animal's lungs. This chain reaction eventually destroys enough cells and results in pneumonia. Non-leukotoxic varieties of this bacterium are thought to be relatively benign.

Mannheimia haemolytica: More research is beginning to point toward this bacterium as a prime culprit in many pneumonia outbreaks. Like *P. multocida*, there are leukotoxic and non-leukotoxic varieties of this organism. The leukotoxic variety of this bacterium is believed to be the dangerous one for bighorn sheep. This bacterium is notoriously hard to culture; being easily overgrown by other bacteria on culture plates. Some researchers speculate the leukotoxic variety of *M. haemolytica* has been responsible for most catastrophic, all-age sheep die-offs throughout the west but was not implicated because of the difficulties associated with culturing and identifying the species.

Mycoplasma ovipneumoniae: This bacterium may be tied to pneumonia issues a bit differently than the 3 bacteria mentioned above. Investigators have consistently tried to link the 3 bacteria above to all-age die-offs in sheep populations. These are catastrophic events where a large percentage of a population may die in a very short period. This is what occurred in the Whiskey Mountain Sheep herd 20 years ago. Since that time pneumonia has primarily manifested itself in lambs with adult sheep being largely unaffected in this population. Annually we observe a reasonable number of lambs migrating onto winter range in the fall. Through fall and early winter lambs can be seen coughing violently and lamb numbers drop steadily. Our lab personnel

have consistently isolated *M. ovipneumoniae* from dead lambs. In addition, examination of lungs from these lambs has consistently revealed damage typical of pneumonia caused by Mycoplasma bacteria. Thus, we suspect this bacterium may be at least partly responsible for perennial pneumonia impacting primarily juveniles in the Whiskey Mountain population.

Other pathogens thought to have potential links to pneumonia in wild sheep include several virus species and lungworm (*Protostrongylus spp*.). Most researchers now believe the most likely culprit is some combination of the aforementioned bacteria. The task of identifying a specific cause of pneumonia in wild sheep populations is compounded by the fact bacteria associated with outbreaks have numerous sub-species, bio-types and strains (Miller et. al., 2012). Until recently, analytical lab techniques were not refined sufficiently to identify many of the sub-specific variations in bacteria. Even now, positive identification of bacteria to sub-specific categories is extremely difficult due to competition between bacteria on culture plates and a lack of knowledge regarding specific bacterial genes and their relationship to toxicity (Weehausen et. al., 2011). Further complicating the issue is the fact unknown environmental conditions may heavily influence the length and severity of pneumonia outbreaks. The state of knowledge regarding pneumonia in wild sheep populations is of interest to the Wyoming Game & Fish Department (WGFD) since several bighorn sheep populations in the state have had known or suspected bighorn sheep die-offs over the past few decades. Of note is the Whiskey Mountain Bighorn Sheep population which experienced a catastrophic, all age, pneumonia die-off during the 1990-91 winter. Managers monitoring this die-off estimated the initial event resulted in 30%-40% mortality in the population. Further, managers believed the population would respond similar to other wild sheep populations experiencing catastrophic, all age, die-offs with several years of low lamb recruitment followed by better survival and subsequent population growth (Ryder et. al., 1992). Instead, this population has continued to slowly decline for over 20 years. The prolonged decline is not associated with catastrophic pneumonia outbreaks but appears related to persistent pneumonia in lambs annually and poor lamb survival (Figure 1). The decline in annual recruitment is quite noticeable following the all age die-off in 1991. Adults in the population appear to be largely unaffected by lingering pathogens in the population. The phenomenon of persistent pneumonia in lambs has been noted in other bighorn sheep herds as well (Sirochman, et. al., 2012). It remains unclear why some wild sheep populations recover following all age die-offs while others suffer persistent, long-term declines primarily associated with pneumonia in lambs. It is also unknown if the same pathogens responsible for all age die-offs result in chronic, annual lamb pneumonia or if different bacteria are the cause of persistent, low lamb recruitment.

Figure 1. Lamb/Ewe ratios for the Whiskey Mountain Bighorn Sheep herd.
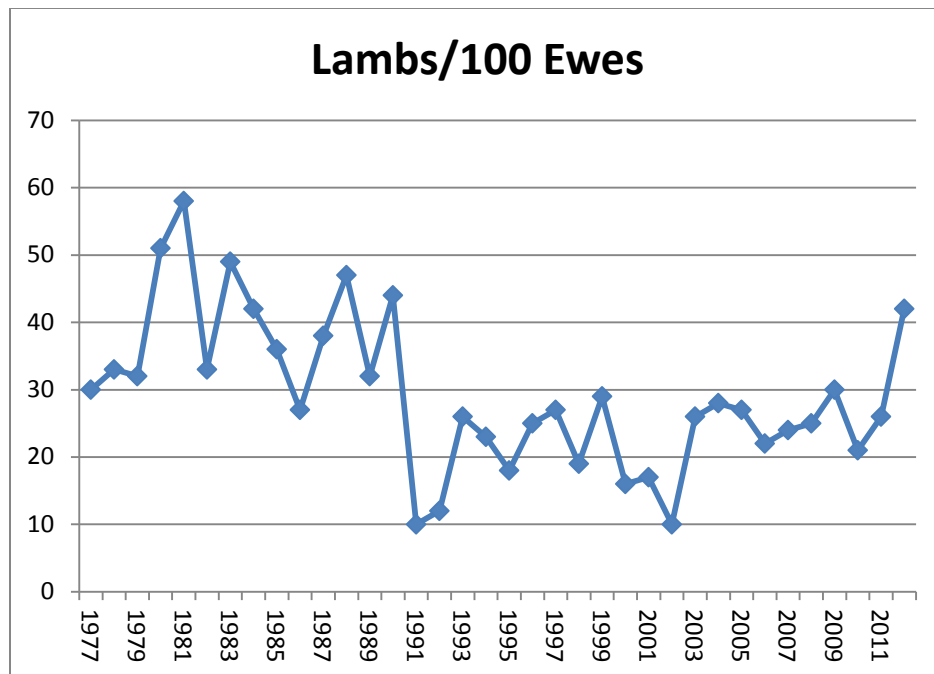
While researchers have continued to try to identify sub-specific varieties of pathogens responsible for both all age die-offs and persistent lamb pneumonia in wild sheep populations, management agencies have taken a somewhat haphazard approach to treating infected populations in an attempt to anecdotally identify actions that may decrease the severity/longevity of pneumonia outbreaks. To date, it appears management actions prescribed and implemented have not lessened the impact of pneumonia outbreaks on wild sheep populations (Sirochman, et. al., 2012; Coggins, 2006). Repeated attempts by state wildlife management agencies to treat impacted sheep populations with antibiotics, anthelmintics, and dietary supplements have all proven to be ineffective at lessening pneumonia impacts. Additionally, euthanizing clinically sick sheep in affected populations appears to have a marginal effect at best on disease severity in populations (Edwards, et. al., 2012). Over the past 6 years, the WGFD attempted to reduce pneumonia impacts in the Whiskey Mountain Sheep herd by administering anthelmintic medication, mineral supplementation, and selective culling of clinically sick animals. None of these management actions had a notable impact on the population.

In 2012, the WGFD made the decision to collect a large number of biological samples for the Whiskey Mountain population to test for the prevalence of various pathogens as well as identify pathogens to a sub-specific level. The intent of the project was to build a library of pathogens in the population so the agency can take proactive management actions in the future should effective management techniques be identified.

Methods

Prior to the 1991 all age die-off in the Whiskey Mountain Bighorn Sheep herd, sheep were trapped annually and a number were removed for transplant to other locations. This process was done to reduce sheep numbers on winter range as well as augment/establish sheep populations in other locations. Because of this historical action, several key winter sites utilized by this population have infrastructure to erect large drop nets for capturing sheep. For this disease sampling project, 2 sites (Torrey Rim and Sheep Ridge) were selected for sheep baiting/capture. Prior to the trapping operation, sheep were baited for 2 weeks using a mixture of apple pulp and second cutting, certified weed free alfalfa.

On January 12 and 13, 2012, sheep were trapped on Torrey Rim and Sheep Ridge respectively. A total of 36 sheep were trapped on Torrey Rim and 11 sheep were trapped on Sheep Ridge. Department personnel and volunteers from other agencies and the public were present to keep sheep immobilized under the drop nets. Veterinary Services personnel took tonsil and nasal swabs and blood samples. Tonsil and nasal swabs were placed in port-a-cul tubes and refrigerated with the blood samples.

As a second facet to this project, 3 ewes were immobilized on Torrey Rim on April 25, 2012. The ewes were fitted with GPS transmitter collars and released. Personnel then attempted to re-capture these ewes on high elevation summer range to collect blood samples to test for dietary intake of trace minerals throughout the summer (primarily selenium). There has been speculation sheep in this population may be more susceptible to pneumonia due to a lack of selenium in their summer diet (Hnilicka, et. al., 2002). Despite this speculation, no samples have ever been collected to definitively show these sheep suffer from trace mineral deficiency.

Results

A detailed listing of lab analysis results is listed in Appendix A. Following is a summary of the trapping/testing results.

In total, we captured 47 sheep. The sample included 40 adult sheep (29 ewes, 11 rams) and 7 juveniles (5 ewes, 2 rams) (Table 1).

Table 1. Age and sex of captured sheep, January 2012.

Location	**# of Sheep**	Adult ♀	Juvenile ♀	Adult ♂	Juvenile ♂
Sheep Ridge	**11**	8	0	3	0
Torrey Rim	**36**	21	5	8	2

All bacteria discussed earlier were found in the Whiskey Mountain Bighorn Sheep Herd (Figure 2). Most notable is that 46 of the 47 sampled sheep were carrying *B. trehalosi*. This suggests *B. trehalosi* is ubiquitous in the population. The impacts to sheep from this bacteria are not entirely clear but researchers now believe this organism may not have many health implications for bighorn sheep. Our results tend to support that conclusion. If *B. trehalosi* were somehow associated with all-age sheep die-offs, we would expect significant adult mortality in addition to low lamb recruitment in this population given the prevalence of the bacteria.

Figure 2. Presence and frequency of bacteria species in the Whiskey Mountain Bighorn Sheep Herd
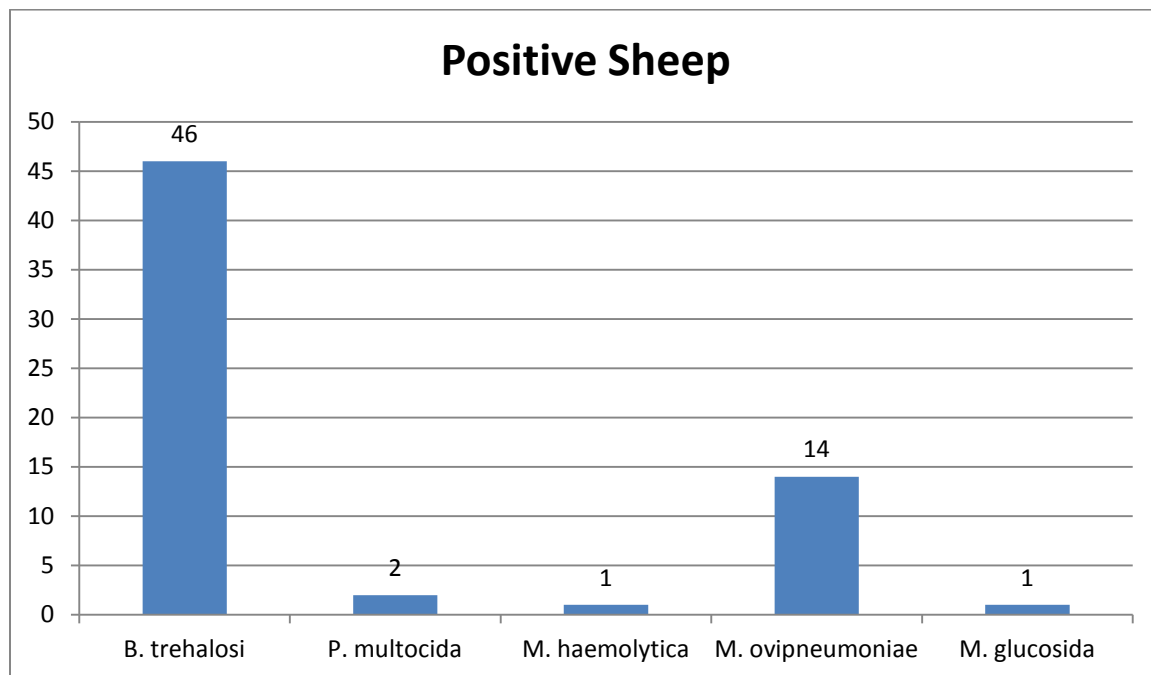
One adult ewe and 1 adult ram (2 sheep) tested positive for *P. multocida*. As mentioned above, we think this bacterium may be problematic but likely only if it is the leukotoxic positive type. Both the *P. multocida* samples from our sheep were leukotoxic negative.

Barely noticeable in this sample is the presence of *M. haemolytica*. Although this finding looks relatively insignificant given its frequency in the sample, it may be one of the more critical things found. This is the bacterium several researchers are keying in on as the main culprit in all-age sheep die-offs. In particular, the leukotoxic variety of this bacterium may have devastating consequences in a sheep population if animals are subjected to nutritional or environmental stress. The *M. haemolytica* sample we collected was leukotoxic positive.

Of the 47 sheep sampled, 14 were positive for *Mycoplasma ovipneumoniae*. This constitutes 30% of the sheep. Again, we are not sure the implications, but we suspect this bacteria may be associated with perennial lamb pneumonia problems.

Finally, we found 1 adult ewe carrying *Mannheimia glucosida*. This bacteria is not typically mentioned in conjunction with bighorn sheep pneumonia. The WGFD has never identified this bacterium in any Wyoming bighorn sheep population and it does not appear to have been implicated in die-offs in other states. Its presence does raise a few concerns. It is a species of *Mannheimia* and thus closely related to *Mannheimia haemolytica* which is suspected to be particularly deadly. Also, the *M. glucosida* bacterium we found was leukotoxic positive. Again we suspect any leukotoxic bacteria may be problematic.

In addition to the bacteria above, several viruses have been linked to bighorn sheep pneumonia. Our results showed no significant exposure to any viruses associated with pneumonia in sheep.

The secondary objective for this study, to collect blood samples from ewes on summer range and test for dietary mineral intake, was not achieved. Personnel were unable to get close enough to the collared ewes on summer range to dart and immobilize them. Movement data from the 3 collared ewes is shown in Appendix B. Spring and fall migration routes utilized by the ewes were similar to routes used by sheep in previous movement/migration studies in this herd. Of note is that one of the collared ewes had a broken rear leg but still used the same migration routes and rugged summer range as other sheep. No unusual summer range use was noted from the collar data.

Management Recommendations

The Whiskey Mountain bighorn sheep herd has suffered from pneumonia related problems for over two decades. First the herd experienced a catastrophic die-off and has since experienced chronic lamb survival problems also thought to be linked to pneumonia. Although both issues are pneumonia related, the root causes of the original die-off and chronic pneumonia may be different. When the herd experienced the original die-off, laboratory techniques were not refined enough to accurately identify all pathogens likely present in the population. It is now known a number of bacteria involved in the wild sheep/pneumonia issue were extremely difficult to culture 20 years ago. Lab techniques have since advanced to allow researchers to more accurately identify suspected bacterial pathogens. Despite advancements, researchers still believe more work needs to be done to effectively identify pathogens present in wild sheep populations (Miller, et. al., 2012). As advances occur, it appears more likely the causes of all age, catastrophic die-offs may be different than chronic lamb pneumonia as seen in herds like Whiskey Mountain. This project was a critical first step in identifying the community of pathogens present in the Whiskey Mountain Bighorn Sheep Herd.

Immediately following this project, the herd had excellent lamb survival through the 2012/13 winter. The reasons for this following 20 years of high lamb mortality are unknown. Regardless, lab techniques for bacterial identification continue to advance and may allow for bacterial identification at a sub-specific level necessary to identify the true culprits for chronic lamb pneumonia in sheep populations. Improved lab techniques make it increasingly likely it will be possible to identify pathogens at a sub-specific level that may prove necessary to take effective management action in the future. Once managers have a more refined picture of the causes for both all age die-offs and chronic lamb pneumonia it is likely some techniques to minimize the effects of bacterial infections can be developed. Until then, the WGFD will continue to focus attention on this important bighorn sheep population and monitor the prevalence of disease causing pathogens.

Literature

Besser, T. E., M. A. Highland, K. Baker, E. F. Cassirer, N. J. Anderson, J. M. Ramsey, K. Mansfield, D. L. Bruning, P. Wolff, J. B. Smith, J. A. Jenks. 2012. Causes of pneumonia epizootics among bighorn sheep, western United States, 2008-2010. Emerging Infectious Diseases 18(3): 406-414.

Coggins, V. L. 2006. Selenium supplementation, parasite treatment, and management of bighorn sheep at Lostine River, Oregon. Biennial Syomposium o the Northern Wild Sheep and Goat Council 15: 98-106.

Edwards, V. L., J. Ramsey, C. Jourdonnais, R. Vinkey, M. Thompson, N. Anderson, T. Carlsen. 2012. Situational agency response to four bighorn sheep die-offs in western Montana. Biennial Symposium of the Northern Wild Sheep and Goat Council 17: 29-50.

Hnilicka, P. A., J. Mionczynski, B. J. Mincher, J. States, M. Hinschberger, S. Oberlie, C. Thompson, B. Yates, D. D. Siener. 2002. Bighorn sheep lamb survival, trace minerals, rainfall, and air pollution: are there any connections? Biennial Symposium of the Northern Wild Sheep and Goat Council 13: 69-94.

Miller, D. S., G. C. Weiser, A. C. Ward, M. L. Drew, P. L. Chapman. 2012. Pasteurellaceae isolated from bighorn sheep (Ovis canadensis) from Idaho, Oregon, and Wyoming. Am. J. Vet. Res. 73(7): 1024-1028.

Ryder, T. J., E. S. Williams, K. W. Mills, K. H. Bowles, E. T. Thorne. 1992. Effect of pneumonia on population size and lamb recruitment in Whiskey Mountain bighorn sheep. Biennial Symposium of the Northern Wild Sheep and Goat Council 8: 136-146.

Schommer, T. J., M. M. Woolever. 2008. A Review of disease related conflicts between domestic sheep and goats and bighorn sheep. USDA Forest Service General Technical Report RMRS-GTR-209.

Sirochman, M. A., K. J. Woodruff, J. L. Grigg, D. P. Walsh, K. P. Huyvaert, M. W. Miller, L. L. Wolfe. 2012. Evaluation of management treatments intended to increase lamb recruitment in a bighorn sheep herd. Journal of Wildlife Diseases 48(3): 781-784.

Weehausen, J. D., S. T. Kelley, R. R. Ramey II. 2011. Domestic sheep, bighorn sheep, and respiratory disease: a review of the experimental evidence. California Fish and Game 97(1): 7-24.

Appendix A. Lab results from analysis of biological samples taken from 47 bighorn sheep in the Whiskey Mountain Bighorn Sheep herd; January 12 and 13, 2012.

Eartag	Date Received	Samp collect	Age	Sex	Trap Location	Blood (red top)	Nasal	Tonsil	Blood (purple top)
S3324	1/13/2012	1/13/2012	6+	F	Sheep Ridge		2	2	
S3526	1/13/2012	1/13/2012	3.5	M	Sheep Ridge	2	2	2	1
S3527	1/13/2012	1/13/2012	A	F	Sheep Ridge	2	2	2	1
S3528	1/13/2012	1/13/2012	5	F	Sheep Ridge	2	2	2	
S3530	1/13/2012	1/13/2012	3	F	Sheep Ridge	2	2	2	
S3531	1/13/2012	1/13/2012	1?	M	Sheep Ridge	2	2	2	
S3532	1/13/2012	1/13/2012	A	M	Sheep Ridge	2	2	2	
S3533	1/13/2012	1/13/2012	A	F	Sheep Ridge	2	2	2	
S3534	1/13/2012	1/13/2012	A	F	Sheep Ridge	2	2	2	1
S3537	1/13/2012	1/13/2012	4	F	Sheep Ridge	2	2	2	
S3477	1/13/2012	1/12/2012	A	F	Torry Rim	1	2	2	
S3479	1/13/2012	1/12/2012	A	F	Torry Rim		2	2	
S3481	1/13/2012	1/12/2012	A	F	Torry Rim	2	2	2	
S3482	1/13/2012	1/12/2012	2+	F	Torry Rim		2	2	
S3484	1/13/2012	1/12/2012	A	F	Torry Rim		2	2	
S3485	1/13/2012	1/12/2012	A	F	Torry Rim		2	2	
S3486	1/13/2012	1/12/2012	yrl	F	Torry Rim		2	2	
S3488	1/13/2012	1/12/2012	4	M	Torry Rim	2	2	2	
S3489	1/13/2012	1/12/2012	A	M	Torry Rim	2	2	2	
S3490	1/13/2012	1/12/2012	juv	F	Torry Rim	2	2	2	
S3491	1/13/2012	1/12/2012	4+	F	Torry Rim	2	2	2	
S3493	1/13/2012	1/12/2012	yrl	F	Torry Rim	2	2	2	
S3494	1/13/2012	1/12/2012	2	M	Torry Rim	2	2	2	
S3495	1/13/2012	1/12/2012	3	F	Torry Rim	1	2	2	
S3496	1/13/2012	1/12/2012	4+	M	Torry Rim	2	2	2	1
S3498	1/13/2012	1/12/2012	juv	M	Torry Rim	2	2	2	
S3500	1/13/2012	1/12/2012	3	F	Torry Rim	2	2	2	1
S3502	1/13/2012	1/12/2012	A	M	Torry Rim		2	2	

Eartag	Date Received	Samp collect	Age	Sex	Trap Location	Blood (red top)	Nasal	Tonsil	Blood (purple top)
S3503	1/13/2012	1/12/2012	A	F	Torry Rim	2	2	2	
S3504	1/13/2012	1/12/2012	A	F	Torry Rim	2	2	2	
S3505	1/13/2012	1/12/2012	2	F	Torry Rim	2	2	2	1
S3506	1/13/2012	1/12/2012	4	F	Torry Rim	2	2	2	1
S3507	1/13/2012	1/12/2012	A	F	Torry Rim		2	2	
S3508	1/13/2012	1/12/2012	4+	M	Torry Rim	2	2	2	
S3510	1/13/2012	1/12/2012	A	F	Torry Rim	1	2	2	
S3511	1/13/2012	1/12/2012	4	M	Torry Rim	1	2	2	1
S3515	1/13/2012	1/12/2012	A	F	Torry Rim	2	2	2	1
S3516	1/13/2012	1/12/2012	juv	F	Torry Rim	1	2	2	
S3517	1/13/2012	1/12/2012	3	F	Torry Rim	2	2	2	
S3518	1/13/2012	1/12/2012	juv	F	Torry Rim	1	2	2	
S3519	1/13/2012	1/12/2012	juv	F	Torry Rim	2	2	2	
S3521	1/13/2012	1/12/2012	2	M	Torry Rim	2	2	2	
S3521	1/13/2012	1/12/2012	A	F	Torry Rim	2	2	2	
S3522	1/13/2012	1/12/2012	juv	F	Torry Rim	2	2	2	
S3523	1/13/2012	1/12/2012	3	F	Torry Rim	2	2	2	1
S3536	1/13/2012	1/12/2012	2	M	Torry Rim	2	2	2	

Eartag	Mycoplasma culture Nasal	Mycoplasma PCR Nasal	Pasteurella culture Tonsil	Leukotoxin/Pasteurella PCR Tonsil (- = Neg/+ = Pos)	Lead	Comments	BRSV	OPP/CAE	IBR	PI-3
S3324	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	
S3526	NSI	ND	B. trehalosi, P. multocida	Lkt - B. trehalosi	0.027 ppm					
S3527	+3M	M.ovi	B. trehalosi	Lkt - only lkt PCR run	0.025 ppm		<1:4	NEG	<1:4	1:128
S3528	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	
S3530	NSI +4C	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	1:32
S3531	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	1:8
S3532	NSI +1 M. arginini like organism	ND	NSI	Lkt - only lkt PCR run		one tonsil swab left in cooler and frozen, 1 haemolytic colony, organism on top of media	<1:4	NEG	<1:4	1:512
S3533	+1M (day 6 or7)	M.ovi	B. trehalosi, P. multocida	Lkt - only lkt PCR run			<1:4	NEG	<1:4	

Eartag	Mycoplasma culture Nasal	Mycoplasma PCR Nasal	Pasteurella culture Tonsil	Leukotoxin/Pasteurella PCR Tonsil (- = Neg/+ = Pos)	Lead	Comments	BRSV	OPP/CAE	IBR	PI-3
S3534	NSI	ND	B. trehalosi	Lkt - only lkt PCR run	0.023 ppm		<1:4	NEG	<1:4	1:128
S3537	NSI	ND	B. trehalosi	Lkt - only lkt PCR run						
S3477	NSI	ND	B. trehalosi	Lkt - B. trehalosi						
S3479	NSI	ND	B. trehalosi	Lkt - B. trehalosi						
S3481	+2M	M.ovi	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	
S3482	NSI +2C	ND	B. trehalosi	Lkt + Mannheimia species (ID as M. glucosida) and Lkt - B. trehalosi		haemolytic colonies but not M. haemolytica per PCR				
S3484	+2M	M.ovi - weak band	B. trehalosi	Lkt - B. trehalosi						
S3485	NSI +3C	ND	B. trehalosi, M. haemolytica	Lkt + M.haemolytica and Lkt - B. trehalosi						
S3486	NSI	ND	P. multocida	Lkt - only lkt PCR run			<1:4	NEG	<1:4	
S3488	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	1:256
S3489	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	
S3490	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	<1:4
S3491	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	
S3493	NSI	M.ovi - weak band	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	1:128
S3494	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	1:256
S3495	NSI	ND	B. trehalosi	Lkt - B. trehalosi						
S3496	NSI +3C	ND	B. trehalosi	Lkt - only lkt PCR run	0.031 ppm		<1:4	NEG	<1:4	1:64
S3498	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	<1:4
S3500	NSI	ND	B. trehalosi	Lkt - only lkt PCR run	0.034 ppm		<1:4	NEG	<1:4	
S3502	NSI	ND	B. trehalosi	Lkt - only lkt PCR run						
S3503	NSI +4C	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	
S3504	NSI +2C	M.ovi	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	
S3505	NSI	ND	B. trehalosi	Lkt - B. trehalosi	0.031 ppm					
S3506	NSI	ND	B. trehalosi	Lkt - only lkt PCR run	0.066 ppm		<1:4	NEG	<1:4	
S3507	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	
S3508	NSI	M.ovi - weak band	B. trehalosi	Lkt - B. trehalosi						
S3510	+4M	M.ovi	B. trehalosi	Lkt - B. trehalosi						
S3511	+2M	M.ovi - weak band	B. trehalosi	Lkt - B. trehalosi	0.036 ppm					
S3515	NSI	ND	B. trehalosi	Lkt - only lkt PCR run	0.015 ppm		<1:4	NEG	<1:4	1:64

Eartag	Mycoplasma culture Nasal	Mycoplasma PCR Nasal	Pasteurella culture Tonsil	Leukotoxin/Pasteurella PCR Tonsil (- = Neg/+ = Pos)	Lead	Comments	BRSV	OPP/CAE	IBR	PI-3
S3516	NSI	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	<1:4
S3517	NSI	ND	B. trehalosi	Lkt - only lkt PCR run						
S3518	+3M	M.ovi - weak band	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	<1:4
S3519	NSI +4C	M.ovi	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	<1:4
S3521	+3M	M.ovi	B. trehalosi	Lkt - B. trehalosi						
S3521	+2M	M.ovi	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	1:128
S3522	+4M	M.ovi	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	<1:4
S3523	NSI +4C	ND	B. trehalosi	Lkt - only lkt PCR run	0.064 ppm					
S3536	NSI +2C	ND	B. trehalosi	Lkt - only lkt PCR run			<1:4	NEG	<1:4	1:64

Location data for collared sheep 149.06
4/25/12 to 11/15/12

Location data for collared sheep 149.10
4/25/12 to 11/15/12